

Original Research

Radiological Outcome of Bony Fusion After Single-Level Anterior Cervical Discectomy and Fusion Using Iliac Crest Graft vs. Polyetheretherketone Cage in Cervical Spondylosis

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ABSTRACT

Objective: To compare the surgical outcome of iliac crest graft and polyetheretherketone in anterior cervical discectomy and fusion (ACDF) in cervical spondylosis in terms of radiographic features.

Materials & Methods: It was a randomized controlled trial study in the Neurosurgery Department of Services Hospital, Lahore. Patients were recruited by non-probability, purposive sampling, followed by randomization by the lottery method and divided into two equal groups, i.e. (Group A) Iliac crest graft and (Group B) Polyetheretherketone cage.

Results: In this study, a total of 42 patients were included; 28(66.67%) patients were male, and 14(33.33%) were female, and having mean age $\pm$ SD 47.62 $\pm$ 6.85 years, with a range of 35- 60 years. In group A, 21 patients underwent an iliac crest autograft, while in group B, 21 patients underwent a polyetheretherketone cage. In the 3rd post-operative month, 7 patients (33.3%) with an iliac crest bone graft and 8 patients (38.1%) with a Polyetheretherketone cage had trabecular bone formation ($p=0.747$). In the 6th post-operative month, 6 patients (28.6%) with an iliac crest bone graft and 14 patients (66.7%) with a Polyetheretherketone cage had bridging bone formation ($p=0.013$). In the iliac crest graft group, 15(71.4%) patients and in the Polyetheretherketone cage group 17 (81.0%) patients had < 2 mm motion of the spinous process on flexion-extension X-rays (0.469). In the iliac crest graft group, 15 (71.4%) patients and 5 (23.8%) patients in the PEEK cage group had a 25% reduction in disc height $p=0.002$.

Conclusion: ACDF with a PEEK cage has better fusion results than an iliac crest graft in terms of radiographic features. Hence, the PEEK cage can be opted for in ACDF.

Keywords: ACDF, PEEK cage, iliac crest, Polyetheretherketone cage.

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INTRODUCTION

The cervical spine is the most mobile portion of the spine and is more prone to degenerative spine changes like cervical disc herniation, cervical spine stenosis, ossified posterior longitudinal ligament and osteophyte formation. Cervical spondylosis describes a variety of progressive degenerative changes that affect all components of the cervical spine (i.e., intervertebral discs, facet joints, Luschka joints, ligamentum flavum, and lamina). This is a normal aging process that affects most people in their 50's.^{5,16}

These changes are related to age, smoking, and other factors. Degenerative cervical spine changes may cause compression on the spinal cord or cervical nerve roots, leading to myelopathy & radiculopathy, respectively. Neck discomfort is the most typical symptom of symptomatic cervical spondylosis.¹

The majority of patients with radiographic spondylotic changes in the cervical spine are asymptomatic, with 25% under 40 years, 50% over 40 years, and 85% over 60 years of age. C₅-C₆ and C₆-C₇ are the levels that are affected most commonly.¹

To evaluate these patients, the following investigations are done: X-rays of the cervical spine in AP & Lateral views, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). MRI is the technique of choice for assessing soft tissues and the neuronal structure.

The signs and symptoms will determine the cervical spondylosis therapy plan. Pharmacologic treatment, including painkillers, can be given. Non-steroidal anti-inflammatory drugs (NSAID's), steroids, muscle relaxants, anticonvulsants, antidepressants and physiotherapy for 4-6 weeks are used in non-surgical management.⁷ Surgical management includes decompression using anterior and posterior approaches. In the anterior approach, anterior cervical discectomy and fusion using an iliac crest autograft or

Polyetheretherketone (PEEK) cage is used, followed by fixation with plating.

Due to its stability, ACDF employing an iliac crest autograft is regarded as best, but it carries significant donor-site morbidity, hematoma formation, infection and pain, etc. These morbidities led to the development of newer techniques, such as a PEEK cage. This technique lacks donor-site morbidity, but it is not cost-effective. The purpose of this study is to compare bony fusion between two of the most common fusion grafts: iliac crest autograft and PEEK cage allograft, among patients undergoing ACDF in the Neurosurgical facility of Services Hospital, Lahore.

MATERIAL & METHODS

Study Design

It was a randomized controlled trial (NCT07739979, ClinicalTrials.gov PRS) in the Neurosurgery Department of Services Hospital, Lahore, from February 2022 to March 2023, with 6 months follow-up, in Services Hospital, Lahore, after taking IRB approval (Ref. no. IRB/2020/727/SIMS dated: 05/10/2021).

Sample Size

A sample size of 42 patients was estimated by using a 5% level of significance, 90% power of the test, with the expected percentage of autograft as 30% and PEEK cage as 6.66%.¹⁵

$$n = \frac{Z_{1-\alpha} \sqrt{(-P)} + Z_{1-\beta} \sqrt{P(-P) + P(-P)}}{(P_1 - P_2)^2}$$

Z_{1-α} = Confidence level 95% = 1.96

Z_{1-β} = Power of test = 90%

P₁ = Population Proportion I = 30%

P₂ = Population Proportion II = 6.66%

Patients were equally divided into two groups:

Group A: Patients who undergo ACDF with auto graft.

Group B: Patients who undergo ACDF with PEEK cage.

Inclusion Criteria

In our study, patients were included with an age of 20- 60 years, both male and female, and having

one level of disc disorder between C3-C7 with radiculopathy/myelopathy, no previous ACDF Surgery, and Cervical Spine traumatic injury.

Exclusion Criteria

Patients who had previous cervical spine surgery, had more than one level of pathology, patients who needed posterior instrumentation, having infection/Caries Spine/Osteomyelitis, etc. and had malignancy.

Data Collection

42 patients who met the eligibility requirements were accepted from the neurosurgical ward at Services Hospital, Lahore. After receiving written informed consent, name, age, gender, and duration demographic factors were also documented. Then, using a lottery system, two groups were formed. In group A, bone transplant, plating, and ACDF were all carried out. In group B, a PEEK cage and plating were used. Under general anesthesia, the patient was positioned in the supine position with the head slightly extended. After aseptic measures, the standard right anterior Cloward approach was used to mark the diseased level with the aid of the C-arm. A skin incision was made, the platysma was dissected, and blunt dissection was made medial to the sternocleidomastoid muscle to reach the desired vertebral level. After opening the disc level, the disc, posterior longitudinal ligament and osteophytes were removed. Before fusion, cartilage from both the upper endplate and lower endplate was removed, and the hard subchondral bone underneath was exposed. Autologous bone graft or a PEEK cage was used to perform the fusion, followed by anterior fixation with a titanium locked plate. Patients were moved to the post-surgical ward following surgery. A predesigned proforma was used to collect information. The proforma was filled during admission, discharge and follow-up by X-rays and computed tomography scans of the cervical spine, following

which the radiographic findings were entered into the data analysis software.

Radiographic Fusion and Stability Criteria

To assess fusion, radiographs and computed tomography scans of the cervical spine were done at 1, 3 and 6 months. The presence of bony trabeculae between the graft and endplates and absence of a radiolucent gap on CT scan, as well as the development of bridging bone anterior or posterior to the cage (PEEK) across the endplates, motion of the spinous process, and disc height between the endplates were used to evaluate fusion and stability by an independent radiologist.

Data Analysis

Data were analyzed on SPSS version 26. Categorical variables like gender were represented as frequency with percentage. Data were stratified by age, gender, presence of bony trabeculae between bony end plates, and graft and formation of bridging bone anterior or posterior to the cage (PEEK) across the end plates at baseline to address effect modifiers. T-test & Chi-square test with a significant P value of ≤ 0.05 were used post-stratification.

RESULTS

Age and gender Incidence

The mean age (SD) was 47.62 ± 6.85 years. In our study, 14 (33.33%) female patients and 28 (66.67%) male patients were included. In the iliac crest graft group, 15 (71.4%) of 21 patients were male, whereas in the PEEK cage group, 13 (61.9%) of 21 patients were male (p-value = 0.513). **Table 1.**

Level of Cervical Spine Disease

In this study, the C4-C5 level of the spine was seen in 19(45.24%) patients; the C5-C6 and C6-C7 level of the spine was observed in 19(45.24%) and 4(9.52%) patients, respectively. **Figure 1.** In the iliac crest graft group, 15 out of 21 patients (71.4%) were male, whereas in the PEEK cage group, 13 out of 21 patients (61.9%) were male (p -value=0.513). At the C4-C5 level, 12 (57.15%) Out of 19 patients who underwent iliac crest graft, 7 (33.33%) received a PEEK cage, while at the C5-C6 level, 9 (42.85%) out of 19 patients underwent iliac crest graft and 10 (47.61%) received a PEEK cage. At the C6-C7 level, 4 (19.04%) patients received a PEEK cage.

Trabecular Bone Formation and Bridging Bone Formation at 1, 3 and 6th Months:

Trabecular bone is the formation of bone between the graft and end plates of superior and inferior vertebrae. According to this study, at the 1st month, no

trabecular bone formation (TBF) was noted in 42(100%) patients, at 3rd month TBF was noted in 15(35.7%) patients and at 6th month TBF was noted in 42(100%) patients. In the iliac crest graft group, TBF at the 3rd month was noted in 7(33.3%) patients, and in the PEEK cage group it was noted in 8(38.1%) patients(p -value=0.747). Bridging bone formation is the formation of bone, anterior or posterior to the cage, across the endplates. At 1 and 3rd months, no bridging bone formation (BBF) was noted in all 42(100%) patients and at the 6th month, no BBF was noted in 22(52.4%) patients. In the iliac crest graft group, BBF at the 6th month was noted in 6(28.6%)

patients, and in the PEEK cage group, it was noted in 14(66.7%) patients (P -value= 0.013). **Table 2.**

Table 1: Age and gender Distribution.

Demographic Data		No. of Patients (n)	Percentage	SD
Gender	Male	28	66.67%	6.85
	Female	14	33.33%	
Age	Minimum	35.00		
	Maximum	60.00		
	Mean	47.62		
Total		42	100.0%	

Level of cervical spine disease and procedure

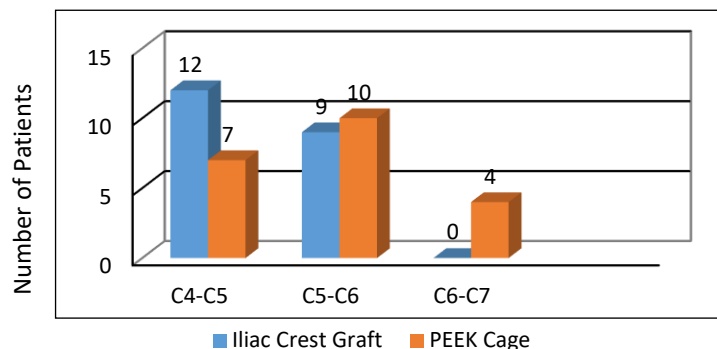


Figure 1: Level of cervical spine disease and procedure

Table 2: Frequency distribution of TBF and BBF at 1, 3, and 6-month follow-up.

		Type of Procedure		Total	P-value
		Iliac Crest Graft	PEEK Cage		
TBF at 3 rd Month	No	14 66.7%	13 61.9%	27 64.3%	0.747
	Yes	7 33.3%	8 38.1%	15 35.7%	
BBF on 6 th Month	No	15 71.4%	7 33.3%	22 52.4%	0.013
	Yes	6 28.6%	14 66.7%	20 47.6%	
Total		42(100.0%)	42(100.0%)		

Motion on Flexion-Extension X-rays

Motion of the spinous process of < 2 mm is marked as fused, while a distance of ≥ 2 mm between spinous processes on flexion and

extension X-rays is marked as unfused. In the iliac crest graft group, < 2 mm motion of the interspinous process on flexion-extension X-rays was found in 15(71.4%) patients, and in the PEEK cage group it was found in 17(81.0%) patients. While > 2 mm motion was observed in 6(28.6%) patients of the iliac crest group and only 4(19.0%) patients in the PEEK cage group. p -value=0.469 (Table 3).

Disc Height Score

Disc height was observed as the distance between endplates, and $> 25\%$ reduction in disc height from postoperative X-rays was noted as unfused. In the iliac crest group, 15(71.4%) patients had a 25% reduction in disc height and 5(23.8%) patients had a PEEK cage at the 6-month follow-up (P -value = 0.002). **Table 4.** Before surgery, mean disc height was 2.55 ± 0.40 mm in the iliac crest group, and 2.49 ± 0.35 mm was in the PEEK cage, with no statistical difference, p -value=0.61. Mean disc height in the iliac crest group was 7.40 ± 0.58 mm, and in the PEEK cage group, its value was 7.78 ± 0.63 mm. At 1-month follow-up, disc height was 7.05 ± 0.60 mm in the iliac crest group and 7.66 ± 0.46 mm in the PEEK cage group, p -value=0.01. At 3 months, disc height was 6.18 ± 0.72 mm, and in the PEEK cage, it was 7.28 ± 0.51 mm. At 6 months, the iliac crest had a

Table 3: Comparison of motion on flexion-extension X-ray between types of procedure.

		Type of Procedure		Total	p-value
		Iliac Crest Graft	PEEK Cage		
Motion on flexion/extension X-ray	< 2 mm	15 (71.4%)	17 (81.0%)	32 (66.7%)	0.469
	> 2 mm	6 (28.6%)	4 (19.0%)	10 (33.30%)	
Total		21 (100.0%)	21 (100.0%)	42 (100.0%)	

Table 4: Percentage of Disc Height Score.

		Iliac Crest Graft	PEEK Cage	Total	p-value
Disc Height Score	Normal	6 (28.6%)	16 (76.2%)	22 (52.4%)	0.002
	Reduction 25%	15 (71.4%)	5 (23.8%)	20 (47.6%)	

Table 5: Disc Height Score at pre-op, post-op, at 1, 3, and 6-month follow-up.

Disc Height (mm)	Group	Mean	SD	t-test	p-value
Pre-Operative	Iliac Crest Graft	2.55	0.40	0.52	0.61
	PEEK Cage	2.49	0.35		
Post-Op	Iliac Crest Graft	7.40	0.58	-2.03	0.08
	PEEK Cage	7.78	0.63		
1 Month	Iliac Crest Graft	7.05	0.60	-3.49	0.01
	PEEK Cage	7.66	0.46		
3 Month	Iliac Crest Graft	6.18	0.72	-5.41	0.004
	PEEK Cage	7.28	0.51		
6 Month	Iliac Crest Graft	5.86	0.81	-4.88	0.002
	PEEK Cage	6.93	0.62		

Table 6: Comparison of total score between types of procedure.

	Type of Procedure	n	Mean	SD	p-value
Total Score	Iliac crest graft	21	1.19	0.87	<0.001
	PEEK Cage	21	0.33	0.48	

disc height of 5.86 ± 0.81 mm, and the PEEK cage had 6.93 ± 0.62 mm with a significant p -value of 0.002. **Table 5.**

In the auto-graft group, the total score was

Table 7: Descriptive statistics of total score.

Total Score	N	42
	Mean	0.76
	SD	0.82
	Minimum	0.00
	Maximum	2.00

1.19±0.87, and its value in the PEEK cage group was 0.33±0.48 (p-value=<0.001) (**Table 6**). The descriptive mean total score across procedure types was 0.76±0.82, with minimum and maximum scores of 0 and 2, respectively (**Table 7**).

DISCUSSION

ACDF is one of the most prevalent spine surgeries to date, and it is the gold standard treatment for many cervical degenerative disc disorders owing to its reliability, low risk and relative simplicity.³ The procedure accomplishes restoration of the lordosis of the cervical spine as well as the physiological height of the intervertebral space, with the removal of the offending disc and osteophyte.⁵ Autologous tricortical iliac crest grafts were once considered the gold standard material for bony fusion between vertebrae; while this is still true, there has been a shift across the landscape, with allograft and interbody fusion cages taking precedence in terms of clinical usage.^{19,20} Autograft is associated with a high rate of donor site morbidity, including chronic pain, restricted mobility, occurrence of secondary infections and formation of neuromas or hematomas.¹⁶ In current study, mean age was 47.62±6.25 years and there were 28(66.66%) males and 14(33.33%) females with higher male-to-female ratio. Similar findings were noted by Malik. M., i.e, there were 58(59.18%) males and 40(40.82%) females, with a mean Age±SD= 49.88±17.83.¹¹

In our study, the PEEK cage had a better fusion rate of 81.1% than the autograft group 71.3%, which was statistically significant with a p-value of 0.001, clearly showing the superiority of the PEEK cage over the iliac crest graft. The same outcome

was noted by Lied, who reported a better fusion rate with the PEEK cage as compared to the bone graft.⁷ In one study by Jae Won Huh, the fusion rates were 93.3% in the iliac crest autograft group and 100% in the PEEK cage, and complication rates were 13% and 3%, respectively, at 1-year follow-up after ACDF.⁴ While in another study, a 100% fusion rate was achieved in the PEEK cage group and 90.3% in the autograft group.¹³ In our study, 81.1% of patients achieved fusion in the allograft PEEK cage group and 71.3% of patients achieved fusion in the autograft group, which is similar to other studies. Another study found that ACDF with a PEEK cage is the procedure of choice for treating cervical spondylotic myelopathy because it has fewer problems and results in a better functional recovery.¹⁵

Our study showed a motion of the spinous process> 2 mm in 6(28.6%) patients in the iliac crest graft group and 4(19%) patients in the PEEK cage group, with p-value=0.469. Similar outcomes were seen in a study.⁸

In this study, disc space height score was normal in 6(28.6%) and 16(76.2%) patients in the iliac crest graft group and PEEK cage, respectively, while a 25% reduction was seen in 15 (71.4%) in the iliac crest graft group and in 5(23.8%) in the PEEK cage group, with a p-value of 0.002, showing better results in the PEEK cage group rather than the iliac crest graft group A. Our findings are similar to other studies,¹³ showing better disc height in the PEEK cage group. In another study conducted at a local healthcare facility in Pakistan, disc height score was better maintained in the PEEK cage group compared with the autograft group.¹¹

The mean score ± SD in the iliac crest graft group was 1.19±0.87 and in the PEEK cage group was 0.33±0.48, which clearly demonstrates better results in the PEEK cage group. Overall comparison of total score shows better fusion rates in the PEEK cage group than the autograft group, in terms of

fusion, movement of interspinous process and disc height score.

ACDF using a PEEK cage packed with various non-structural graft materials is as effective as ACDF with autologous grafts in terms of cervical alignment.^{5,9,12,19}

However, PEEK cages are not cost-effective when compared against autograft.¹⁸ They are, however, more preferable to patients, especially when compared to the donor-site morbidities associated with autograft.¹⁰

RECOMMENDATION

The Polyetheretherketone (PEEK) cage has better results than the iliac crest graft in terms of better fusion and stability.

LIMITATIONS

A multi-centred study and long-duration follow-up of patients are essential to assess for better outcomes.

CONCLUSION

From the findings of this study, we concluded that ACDF using a PEEK cage is associated with better radiological outcomes and lower complication rates compared to ACDF using an iliac crest autograft, which shows a lower fusion rate, graft resorption and donor site morbidity. PEEK cage can be used as an alternative to an iliac crest graft.

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Additional Information

Disclosures: No conflict of interest.

Ethical Review Board Approval: The study conformed to the ethical review board requirements (Ref. no. IRB/2020/727/SIMS)

Human Subjects: Consent was obtained from all patients/participants in this study.

Conflicts of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations.

Other Relationships: All authors have declared that there are no other relationships or activities.

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AI Usage: No AI help was taken during this research process.

AUTHORS CONTRIBUTIONS

Role	Contributing Author(s)	Role	Contributing Author(s)
Conceptualization	Sohaib Ashraf	Data Curation	Sohaib Ashraf
Methodology	Mahak Ali	Writing – Original Draft/Literature Review	Sohaib Ashraf
Software	Obaid ur Rehman	Writing - Review & Editing	Sohaib Ashraf
Validation	Obaid ur Rehman	Visualization	M. Zia Ul Haq
Formal analysis	Obaid ur Rehman	Supervision	Abdullah Haroon
Investigation	Sohaib Ashraf	Project administration	Sohaib Ashraf
Resources	M. Ahsan Abid	Any other (Misc.)	-